DEVELOPMENT OF RENEWABLE ENERGY SOLAR IMPLEMENTED EV IN COLLEGE CAMPUS

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Keywords:

Electric vehicles, EV charging station, Solar MPPT Charge controller, Batteries.

Introduction:

The demand for electric vehicles (EVs) is rapidly increasing due to rising concerns about environmental pollution and depletion of fossil fuels. EVs are considered eco-friendly because they produce zero tailpipe emissions and help reduce greenhouse gases. They also offer better energy efficiency compared to traditional petrol and diesel vehicles. However, most EV charging stations rely on electricity from the conventional power grid. In many areas, this electricity is generated using fossil fuels like coal, which reduces the environmental advantages of EVs.

To overcome this issue, integrating renewable energy sources with EV charging systems is essential. Solar energy is one of the most abundant and sustainable energy sources available. Photovoltaic (PV) panels can convert sunlight directly into electrical energy without causing pollution. This energy can be used immediately for charging vehicles or stored in batteries for later use.

By combining solar power with EV charging infrastructure, the system becomes more environmentally friendly and energy-efficient. It also reduces dependence on non-renewable energy sources and lowers electricity costs over time. College campuses are ideal locations for implementing such systems due to their large open spaces and controlled environments. Additionally, campuses have a growing awareness of sustainability and green technologies among students and staff. Installing solar-powered EV charging stations can serve as both a practical solution and an educational tool. It encourages innovation and promotes the use of clean energy in everyday life.

Overall, integrating solar energy with EV charging is a smart and sustainable approach to meet future energy demands while protecting the environment.

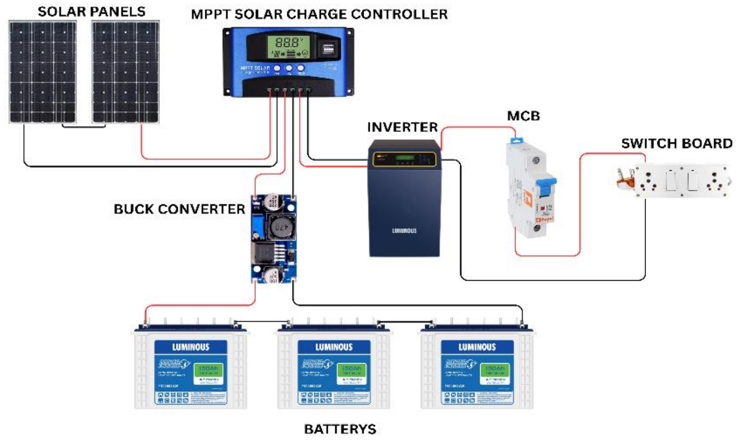

Figure 1: Connection diagram of the EV charging station

Objectives:

1. To design and develop a renewable energy–based solar EV charging system suitable for a university campus environment.
2. To utilize solar photovoltaic (PV) energy as the primary power source for charging electric vehicles.
3. To reduce dependency on conventional grid electricity and minimize carbon emissions.
4. To provide a reliable and efficient EV charging infrastructure that supports sustainable transportation.
5. To optimize energy utilization through proper system design and component selection.

Methodology:

The methodology adopted for the solar-powered EV charging campus follows a systematic step-by-step process to ensure efficient generation, storage, and utilization of energy. Initially, solar energy is captured using photovoltaic (PV) panels, which convert sunlight directly into DC (direct current) electricity through the photovoltaic effect. This generated DC power is then passed to an MPPT (Maximum Power Point Tracking) charge controller, which plays a crucial role in optimizing the voltage and current to extract maximum power from the solar panels under varying environmental conditions. The regulated power from the MPPT controller is then directed to the battery storage system, where electrical energy is stored for later use.

The batteries, typically lead-acid, store the DC energy and are supported by a Battery Management System (BMS) that monitors parameters such as voltage, temperature, and charging cycles to ensure safety and efficiency. When there is a demand for charging an electric vehicle, the stored energy is discharged from the batteries in DC form. If the EV charging system requires AC supply, the DC power is passed through an inverter, which converts it into AC (alternating current) with stable voltage and frequency. A distribution unit then safely delivers this power to the EV charging points.

The system is designed to support off-board charging facility. In off-board charging, the charging station itself performs the power conversion and supplies DC power directly to the

EV battery, allowing faster charging. Additionally, safety devices such as circuit breakers, fuses, and surge protectors are incorporated to protect the system from faults and overloads. During peak sunlight hours, solar energy can be directly used for charging EVs while simultaneously storing excess energy in batteries. During low sunlight or nighttime, the stored battery energy is used to ensure continuous charging. This integrated approach ensures efficient energy management, reliability, and sustainability of the EV charging system.

Result and Conclusion:

The designed solar power system with two panels and three 150Ah batteries is capable of generating and storing sufficient energy for small-scale applications. Under peak sunlight conditions, the system produces close to its maximum output and is able to charge the batteries within approximately 5 to 6 hours. During morning and evening periods, the charging rate decreases due to lower solar intensity, while in cloudy or rainy conditions, the charging becomes very slow and may take up to one or two days. The total usable energy stored in the batteries is around 3.6 kWh, which can support basic electrical loads efficiently. The system performs well for continuous low-power usage such as lighting, fans, and mobile charging. However, due to limited generation capacity, the system cannot support high-power loads. The performance of the system mainly depends on sunlight availability and environmental conditions. Overall, it provides a reliable and eco-friendly energy solution for small applications.

The solar-powered battery system is effective for meeting basic energy needs, especially for hostel students during power shortages or at night. The stored energy can be efficiently utilized for essential loads, ensuring continuous power supply in low-light conditions. The system promotes the use of renewable energy and reduces dependence on conventional electricity sources. However, it is not suitable for heavy loads such as air conditioners or full-scale electric vehicle charging due to limited power capacity. For better performance, proper energy management and usage planning are required, especially during cloudy weather. The system is best used by storing energy during peak sunlight hours and utilizing it during non-sunny periods. It is a cost-effective and sustainable solution for small-scale energy demands. With future improvements like increasing solar panel capacity or battery storage, the system can be enhanced further for higher efficiency and wider applications.

Project Outcome & Industry Relevance:

The project demonstrates a sustainable solution for EV charging using solar energy, reducing dependency on fossil fuels. It helps in minimizing carbon emissions and promotes clean energy usage. The system can be effectively implemented in college campuses, parking areas, and public charging stations. It contributes to the fields of renewable energy, electrical engineering, and smart energy systems. This project also supports the growing EV industry by providing eco-friendly charging infrastructure. Industries such as automobile, energy, and smart city development can benefit from this system. It can reduce electricity costs by using free solar energy. The integration of battery storage ensures continuous charging even during low sunlight. It also creates awareness about green technology among students. The project aligns with global sustainability goals and clean energy initiatives. It can be scaled for commercial applications. Overall, it bridges the gap between renewable energy and transportation.

Working Model:

Figure 2: Working Model of EV Charging Station

This project involves the development of a working model of a solar-powered EV charging station. The system includes solar panels, a charge controller, battery storage, and EV charging output which is shown in Figure 2. Along with the physical model, basic calculations and analysis were also performed to evaluate performance under different conditions.

Simulation/Study:

This project is primarily based on a simulation and theoretical study. The system design and performance were analyzed using software tools and calculations rather than building a complete physical model. Parameters such as solar panel output, battery charging, and EV load were studied under different conditions. The simulation helped in understanding system efficiency, energy flow, and feasibility. It provides a clear idea of how a solar-based EV charging station would work in real-world conditions.

Project Outcomes and Learnings:

1. The project successfully demonstrated a solar-powered EV charging station for efficient energy generation and storage. It proved that small EVs can be charged using renewable energy. The system showed reliable performance with practical charging time.
2. We gained knowledge of solar systems, EV charging, and energy management. We learned how DC power is generated, controlled, and stored. Practical skills in design, wiring, and testing were developed.

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Future Scope:

The project can be further improved by integrating IoT technology for real-time monitoring of charging status and energy usage. Smart mobile applications can be developed for users to locate and book charging slots. The efficiency of the system can be increased by using advanced MPPT charge controllers. Future systems can include fast charging capabilities to reduce charging time. Integration with the smart grid can help in better energy management. Artificial Intelligence can be used to predict energy demand and optimize power usage. The system can be expanded for commercial EV charging stations in cities and highways. Wind energy can also be combined with solar for hybrid power generation. Wireless charging technology can be introduced for more convenience. Better battery technologies can improve storage capacity and lifespan. Government policies and subsidies can support large-scale implementation. The system can be adapted for rural areas where grid electricity is limited. It can also be used in industries, malls, and public transport systems. Research can be done to reduce system cost and increase affordability. Overall, this project has strong potential for future development and real-world applications in sustainable energy solutions.